Claim Rejections Under 35 USC § 112

Applicants respectfully submit that independent Claims 31, 44, 51, and 63 have been amended to overcome the Examiner's previous rejections for the use of negative limitations.

Therefore, Applicants request that the Examiner withdraw the objections to amended claims under 35 USC § 112.

Rejections Under 35 USC § 103

Claims 51-54, 56, 57, 66-69, 63-69, stand rejected under 35 USC 103(a) as being unpatentable over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS.

The Examiner states that "McCullough teaches a nozzle having a primary flow, a primary injector 16, and a secondary injector 18, and valve controllers 22 to direct a flow to vary the effective throat area of the nozzle and perform thrust vectoring (top of col. 2). McCullough further teaches the use of fuel (col. 2, lines 26-28). Alternately, for the controllers, it is clear that the valves require a controller to actuate them. It would have been obvious to one of ordinary skill in the art to employ a software based controller in addition to the valves, in order to provide the necessary control over the thrust vectoring and/or throat control. McCullough do not teach the primary and secondary injectors are inclined to oppose the flow."

The Examiner further states "Ernst teaches that it is old and well known in the thrust vectoring art to employ primary and secondary injectors 1, 3 that are either angled perpendicular to the primary flow (Fig. 1) or included to oppose the flow (Fig. 3) and shows that the effective vector O can be increased by using opposed flow (compared Fig. 3 to Fig. 1)."

With respect to Miller et al., the Examiner states "Miller et al. teach a fixed geometry exhaust nozzle used for gas turbine/turbofan engines (which inherently employ compressors) where the nozzle area is varied by a cross flow injected in the upstream direction (Figs. 2-5) in order to achieve a variable throat area. At the throat, the primary flow reaches the sonic condition. Miller shows on the cover sheet of the paper that the flows from the primary and secondary injectors can be angled to oppose the flow. Miller et al. further teach very low injection angles are possible (see top left of fig. 9) and hence, as the angles are very low, the angles will also be approximately parallel the vector angle, which would also be low."

The Examiner concludes: "It would have been obvious to one of ordinary skill in the art to incline the injectors of McCullough to oppose the flow, as taught by either Ernst or Miller et al., in order to enhance the effectiveness of the thrust vectoring and/or to employ an alternative means of vectoring well established in the art. As for using the nozzle with a jet engine aboard an aircraft, this is taught by the Miller paper. It would have been obvious to one of ordinary skill in the art to employ the nozzle with a jet aircraft, as a well known application of such a nozzle."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claims 31, 44, 51, and 63 that the injected flow skews the sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective

orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

Therefore, Applicants respectfully submit that one would not apply the teachings of McCullough, Ernst, or Miller to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 51-69 stand rejected under 35 USC 103(a) as being unpatentable over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS, as applied above, and further in view of either Kranz et al. (4,351,479) or Warren (3,204,405).

The Examiner states: "McCullough teaches various aspects of Applicant's claimed invention but does not teach the flow is pulsed. Kranz et al. teach a jet engine nozzle 7 having a plurality of injectors (a-f) spaced about the housing, and valve controllers 36 associated with the injectors, the controller directing the injectors to provide an unsteady, i.e., pulsed, fluidic cross flow. The pulsed cross flow is injected to control the effective flow area, throttle and also vector the primary fluidic flow (see especially col. 5, lines 9 and following). The pulsed cross flow partially blocks the opening of the nozzle and can be either symmetric (area control) or asymmetric (thrust vectoring) as desired. Please note that as the effective flow area for the primary fluid flow is controlled, the temperature and pressure of the primary gas is inherently controlled by variation of the primary fluid flow velocity. The pulsed cross flow controller inherently controls the frequency, amplitude and wave form of the pulses. Kranz et al. teach that by employ pulsed flow, more effective deflection of the incoming flow is achieved (col. 1, lines 7 and following). Warren et al. teach a thrust vectoring system for a reaction engine where pulsed flow (col. 9, lines 2 and following, especially circa line 63) is injected at the throat (e.g. Fig. 6a, 11, 121) to provide vectoring of the primary fluid. Warrant also teaches that the pulsed fluid can be fuel. It would have been obvious to one of ordinary skill in the art to employ pulsed flow of the cross flow injected by McCullough, as taught by either Kranz et al. or Warren et al., to more effective control the cross flow penetration of McCullough, and to enhance the thrust vectoring ability."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda

effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse

from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat (see Claims 31, 44, 51, and 63). This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 09/621,795; page 20, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention in Claims 31, 44, 51, and 63.

Therefore, Applicants respectfully submit that one would not apply the teachings of McCullough, Ernst, Miller et al., Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 51-54, 56, 57, 69-65, and 63-39, stand rejected under 35 USC 103(a) as being unpatentable over the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642). The Examiner states: "Miller et al. teach a fixed geometry exhaust nozzle used for gas turbine/turbofan engines (which inherently employ compressors) where the nozzle area is varied by a cross flow injected in the upstream direction (Figs. 2-5) in order to achieve a variable throat area. At the throat, the primary flow reaches the sonic condition. Miller et al. show on the cover sheet of the paper that the flows from the primary and secondary injectors can be angled to oppose the flow. Miller et al. do not teach thrust vectoring. However, it is clear that in a fixed nozzle, thrust vectoring capacities are generally required in order to steer the nozzle, especially in a military aircraft. Miller et al. further teach very low injection angles are possible (see top left of Fig. 9) and hence, as the angles are very low, the angles will also be approximately parallel the vector angle, which would also be low. McCullough teaches a nozzle having a primary flow, a primary injector 16, and a secondary injector 18, and valve controllers 22 to direct a flow to vary the effective throat area of the nozzle and perform thrust vectoring (top of col. 2). McCullough further teaches the use of fuel (col. 2, lines 26-28). Alternately, for the controllers, it is clear that the valves require a controller to actuate them. It would have been obvious to one of ordinary skill in the art to employ a software based controller in addition to the valves, in order to provide the necessary control over the thrust vectoring and/or throat control. It would have been obvious to one of ordinary skill in the art to both control the throat area and

thrust vector the nozzle of Miller et al., as taught by McCullough, in order to add vectoring capabilities to the nozzle of Miller et al."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

Therefore, Applicants respectfully submit that one would not apply the teachings of McCullough and Miller to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 51-69 stand rejected under 35 USC 103(a) as being unpatentable over the AIAA paper of Miller et al. (IAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above and further in view of either Kranz et al. (4,351,479) or Warrant (3,204,405).

The Examiner states: "Miller et al. teach various aspects of Applicant's claimed invention but does not teach pulsing the flows nor the flows being fuel. Kranz et al. teach a jet engine nozzle 7 having a plurality of injectors (a-f) spaced about the housing, and valve controllers 36 associated with the injectors, the controller directing the injectors to provide an unsteady, i.e. pulsed, fluidic cross flow. The pulsed cross flow is injected to control the effective flow area, throttle and also vector the primary fluidic flow (see especially col. 5, lines 9 and following). The pulsed cross flow partially blocks the opening of the nozzle and can be either symmetric (area control) or asymmetric (thrust vectoring) as desired. Please note that as the effective flow area for the primary fluid flow is controlled, the temperature and pressure of the primary gas is

inherently controlled by variation of the primary fluid flow velocity. The pulsed cross flow controller inherently controls the frequency, amplitude and wave form of the pulses. Kranz et al. teach that by employ pulsed flow, more effective deflection of the incoming flow is achieved (col. 1, lines 7 and following). Warren et al. teach a thrust vectoring system for a reaction engine where pulsed flow (col. 9, lines 2 and following, especially circa line 63) is injected at the throat (e.g. Fig. 6a, 11, 121) to provide vectoring of the primary fluid. Warrant also teaches that the pulsed fluid can be fuel. It would have been obvious to one of ordinary skill in the art to employ pulsed flow of the cross flow injected by Miller et al., as taught by either Kranz et al. or Warren et al., to more effective control the cross flow penetration, and to enhance the thrust vectoring ability.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross

flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, Applicants respectfully submit that one would not combine the teachings of Miller, McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 31-35, 37-39, 40-42, 44-46, and 48 stand rejected under 35 USC 103(a) as being unpatentable over Miller et al. and McCullough, and further in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) or AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635).

The Examiner states: "The above prior art teach various aspects of applicant's claimed invention but do not specifically teach a 3-D fixed nozzle. Terrier teaches (fig. 8) that ultra high aspect ratio biconvex aperture nozzles are old and well known in the fixed nozzle art. Justice teaches that it is old and well known in the fixed nozzle art employ an ultra high aspect ratio trapezoid aperture nozzle 33B (col. 2, circa line 63). It would have been obvious to one of ordinary skill in the art employ a 3-D nozzle, including either an ultra high aspect ratio biconvex or trapezoid aperture nozzle, as well known types of fixed nozzles utilized in the art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control

the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single

fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency,

amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 31-50 are rejected under 35 USC 103(a) as being unpatentable over either McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) and further in view of either Kranz et al. (4,351,479) **or** Warren (3,204,405) **or** AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642) and either Kranz et al. (4,351,479) or Warren (3,204,405), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635). The above prior art teach various aspects of Applicants' claimed invention but do not specifically teach a 3-D fixed nozzle. Terrier teaches (fig. 8) that ultra high aspect ratio biconvex aperture nozzles are old and well known in the fixed nozzle art. Justice teaches that it is old and well known in the fixed nozzle art employ an ultra high aspect ratio trapezoid aperture nozzle 33B (col. 2, circa line 63). It would have been obvious to one of ordinary skill in the art employ a 3-D nozzle, including either an ultra high aspect ratio biconvex or trapezoid aperture nozzle, as well as known types of fixed nozzles utilized in the art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims

that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in

Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

Applicants submit that the present invention as recited in Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the

divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

CONCLUSION

Applicants have now made an earnest attempt to place this case in condition for allowance. For the foregoing reasons, and for other reasons clearly apparent, Applicants respectfully request full allowance of the pending claims.

It is believed no additional fees are due with this submission, however, should any fees be determined to be due, the Commissioner is hereby authorized to charge any fees or credit any overpayments to Koestner Bertani LLP Deposit Account No. 50-2240.

Respectfully submitted,

KOESTNER BERTANI LLP

Robert A. McLauchlan
Reg. No.: 44,924
ATTORNEY FOR APPLICANTS

Dated: January 30, 2004

Koestner Bertani, LLP
4201 W. Parmer Lane
Suite A-100
Austin, Texas 78727
(512) 399-4100
(512) 692-2529 (Fax)